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# ECONOMIC EVALUATION of Potential European Pine Shoot Moth Damage in the Ponderosa Pine Region

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## SUMMARY

An examination is made of the regional economic impact that might occur if the European pine shoot moth were to move from its present area of containment in western Washington and British Columbia into the ponderosa pine region of the United States. Analysis is limited to the ponderosa pine type.

Various assumptions are made as to rate of spread of the insect and its survival in destructive numbers at low winter temperatures. Effects on timber harvest and timber-related employment are considered for both the invasion period and the long run, where the long run is a period far enough in the future that access development has been completed and all stands have passed through a period of susceptibility agewise. Results are summarized in table 1.

Over the long run, after long-term development programs have been accomplished, it is estimated that from 4 to nearly 23 million acres of the ponderosa pine type could be affected seriously by the European pine shoot moth. This wide range of possible effects is due to the variation between assumptions as to the temperature and frequency required to kill or inhibit the moth. The corresponding longrun impacts of this infestation include the possible loss of from 651 million to 4,375 million board feet of allowable timber cut per year and the loss of from 11,000, to nearly 74,000 jobs per year.

Table 1.--Summary of effects of potential European pine shoot moth invasion in the ponderosa pine region

| Item | Infested area remaining, low and medium sites[1] | Average curtailment of allowable cut per year[2] | Number of jobs lost[2] | Annual payroll loss[2] | Annual stumpage receipts foregone[2] |
|---|---|---|---|---|---|
| | Thousand acres | Million board feet | | Million dollars | Million dollars |
| 20-year invasion period: | | | | | |
| –20° F.[3] | 3,410 | 400 | 6,800 | 25.6 | 9.1 |
| –15° F.[4] | 760 | 100 | 1,800 | 6.6 | 2.5 |
| 50-year invasion period: | | | | | |
| –20° F.[3] | 5,900 | 700 | 11,700 | 44.4 | 15.8 |
| –15° F.[4] | 1,450 | 200 | 3,600 | 13.4 | 5.0 |
| Long run: | | | | | |
| –20° F.[3] | 22,670 | 4,375 | 73,900 | 279.9 | 38.7 |
| –15° F.[4] | 3,921 | 651 | 11,000 | 41.6 | 7.3 |

[1] For invasion periods, reference is to the end of the period.

[2] Effects are assumed constant during the periods indicated. This follows from an assumption that ultimate growth impact is reflected throughout the period by reduction of the allowable cut.

[3] Assumes a temperature of –20° F., occurring five times every 20 years, will limit or kill the moth.

[4] An alternative assumption that –15° F., occurring four times every 20 years, will limit or kill the moth.

# INTRODUCTION

This report is an estimate of the regional economic impact that might occur if the European pine shoot moth were to move from its present area of containment in western Washington and British Columbia into the ponderosa pine region of the United States.

Since its introduction in 1914, the European pine shoot moth has been a serious attacker of two- and three-needle pines in the Eastern and Central States. It has been especially destructive in forest plantations, as it inhibits growth by boring into and killing buds and developing shoots.

For several years, the insect has been found on nursery stock and on ornamental plantings in the Northwest, notably in Seattle but also at scattered points around Puget Sound and in the Willamette Valley. Efforts to prevent spread of the insect have included uniform plant quarantines among the Western States, designation of a containment area in the State of Washington, and eradication of infested trees found outside the containment area. Owners of infested plants have understood the problem and have worked closely with the Federal and State control personnel. More than $250,000 has been spent on surveys, eradication, and research in the Northwest. None theless, the insect has invaded lodgepole pine stands near Shelton, Wash., and has been found on a native ponderosa pine near Summerland, British Columbia. An infestation on ornamentals in Spokane, Wash., in the pine region, appears to have been eradicated.

Concern with the possibility of ultimate escape of the shoot moth into ponderosa pine stands in eastern Washington or Oregon, and thence throughout the West, led the Northwest Forest Pest Action Council in 1964 to undertake an assessment of the outcome of such an escape. This report is one product of that inquiry. Because western pine forests have not been exposed to damage by this insect, assumptions must be made about shoot moth behavior in the pine region and its biologic effect on host trees. The biologic underpinnings of this report are based on experience with this insect in plantations in Eastern and Central United States and Canada and expert opinion provided by researchers in these regions.

The dollar and employment impact figures given here are oriented to local affected communities. Largely ignored are secondary and substitution effects that may make the shoot moth problem appear quite different when viewed in a national or broad social context.

# ACREAGE IMPACT

The shoot moth's possible occupation of the ponderosa pine region has been divided into three phases. During the first phase, here called the invasion period, the insect is assumed to move outward from one or more initial spot infestations, by means of flight or transportation of infested nursery stock, until the entire region is occupied. On the assumption that stands over 40 years of age would not be damaged economically by insect attack, the second period is recognized, during which merchantable stands in the West are harvested and reproduction becomes susceptible, agewise, to attack. It is assumed that public agencies' long-term, access development policies will be realized during the second period. A third phase, the long run, follows the second period. This analysis is concerned with the invasion period and the long run.

In the Lake States, it has been shown *(6)*[1] that the shoot moth's effect on red pine growth varies chiefly with site quality. Trees growing at a rate of 15 inches or more a year, both before and after establishment, are not seriously damaged. Trees that grow less than 15 inches before establishment but more than 15 inches after establishment will tend to recover from shoot moth attack. Trees growing less than 15 inches a year both before and after establishment will be perennially susceptible to damage by the shoot moth.

From the foregoing, it is assumed that the impact of the European pine shoot moth in the West on low sites will be to completely eliminate the net growth of ponderosa pine; on middle sites it is assumed that, although survival would not be strongly affected, the insects' destruction of terminal buds would lead to a degree of forking and crooking that would materially affect merchantable values. The ponderosa pine region was arbitrarily divided into low, medium, and high site classes: below site index 70, between site index 70 and 100, and above site index 100.

It appears that the shoot moth is not an important damaging agent in that part of the Lake States in which minimum temperatures commonly reach 20° below zero *(10)*. The upper half of table 2 relates this limiting temperature to the ponderosa pine forest. On the assumption that a temperature of -20°F., occurring five times in 20 years, is required to kill or limit the spread of the moth, about 4.8 million acres of low-site area would be protected. At the same time, a balance of some 10.9 million acres of ponderosa pine forest would not be protected because it lies outside that temperature zone.

The lower half of table 2 presents estimates of area which would be protected under an alternative assumption: that a temperature of -15°F., occurring four times in 20 years, would kill or limit the spread of the moth. If this assumption holds, then all of the low-site areas of ponderosa pine forest, for example, would be protected. This comparison of these two assumptions illustrates the key nature of temperature as a limit on shoot moth populations and underscores the need for additional research to provide additional biological information useful for planning control programs.

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[1] Italic numbers in parenthesis refer to Literature Cited, p. 13.

Table 2.-- Estimated acres of ponderosa pine forest type susceptible to European pine shoot moth invasion, by temperature zone, region, and site class

| Limiting temperature and region | Temperature limits moth[1] | | | Temperature not limiting | | |
|---|---|---|---|---|---|---|
| | High site | Medium site | Low site | High site | Medium site | Low site |
| If −20° F. occurs five times in 20 years: | | | Thousands of acres | | | |
| Pacific Northwest *(2)* | -- | -- | -- | 891 | 7,851 | 3,300 |
| California *(14)* | -- | -- | -- | 617 | 1,884 | 1,037 |
| Rocky Mountain States[2] | 56 | 3,268 | 4,838 | 17 | 2,024 | 6,577 |
| Total | 56 | 3,268 | 4,838 | 1,525 | 11,759 | 10,914 |
| If −15° F. occurs four times in 20 years: | | | | | | |
| Pacific Northwest | 891 | 7,851 | 3,300 | -- | -- | -- |
| California | -- | -- | -- | 617 | 1,884 | 1,037 |
| Rocky Mountain States | 73 | 5,292 | 11,415 | -- | -- | -- |
| Total | 964 | 13,143 | 14,715 | 617 | 1,884 | 1,037 |

[1] Based on Kincer *(9)*, figures 7, 8, and 9.

[2] Sources: *( 1,3,4,7,8,14,15,16 )*.

Table 3.-- Estimated acreage of ponderosa pine type of an age to be susceptible to European pine shoot moth invasion and expected annual increase in acreage susceptible[1]
( In acres )

| Low and medium sites, ponderosa pine type | Pacific Northwest | California | Rocky Mountain States | Total |
|---|---|---|---|---|
| Now less than 40 years old: | | | | |
| Outside −20° zone | 440,000 | 300,000 | 1,010,000 | 1,750,000 |
| Outside −15° zone | 0 | 300,000 | 0 | 300,000 |
| Increase, acres per year: | | | | |
| Outside −20° zone | 35,000 | 23,000 | 25,000 | 83,000 |
| Outside −15° zone | 0 | 23,000 | 0 | 23,000 |

[1] The acreage of restockable burns is not included.

However, there is evidence that pine stands cease to be susceptible to shoot moth attack after attaining an age of about 40 years. Thus, not until the long run are the total acreages cited in the foregoing tables being damaged. Until then, some stands will be within infested areas but protected by their ages. The initial acreage that is susceptible, by being both young and infested, and the expected rate of increase in affected acreage through harvesting, are indicated by regions in table 3.

# VOLUME IMPACT

Distinction will be made between shoot moth impact during the invasion period and during the long run. Analysis of the invasion period is based on stand structure and access as it is expected to develop during the next 20 to 50 years. Longrun estimates are founded on a more or less regulated, even-aged forest with negligible problems of access. The longrun assumptions are consistent with present public forest management objectives.

Most of the shoot moth impact is expected to fall on public lands, where the current allowable cut is based on long-term growth expectations. Thus, it is reasonable to assume that, following escape of the moth to the pine region, allowable cut would be adjusted throughout the West, even though the insect had not yet arrived in some areas. The method used here of revising the allowable cut is a generalization of that employed in Region 6, U.S. Forest Service, in which the allowable cut is based on the average of current and prospective growth.

Although the allowable cut is normally computed separately for each working circle, a single calculation is made here for the entire affected area. Because allowable cut during the invasion period is the average of two numbers, only one of which is affected by the insect, an ultimate reduction of growth by 100 percent leads to a reduction in allowable cut of 50 percent during the invasion period. In the long run, of course, allowable cut drops to zero in the affected areas if no merchantable growth is expected.

Growth estimated for uninfested medium sites is 425 and 187 board feet per acre per year for managed and unmanaged stands, respectively. It is assumed that half of medium sites would be placed under intensive management in the long run; the average growth rate on medium sites is then 306 board feet per acre per year.

It was assumed that no low sites would receive intensive silvicultural treatment. A growth rate of 71 board feet per acre per year was assigned to low sites. Table 4 summarizes, by site and length of invasion period, acreage occupied and annual growth not realized at the end of the invasion period. Also shown is the reduction of allowable cut during the invasion period.

Estimates of shoot moth impact in the long run are based on assumptions that infested stands would otherwise be managed for timber production and that all low and medium sites have been susceptible at some time; i.e., their age has been less than 40 years at some time after arrival of the shoot moth. Impact on timber production in the long run on low and medium sites is shown in table 5.

Table 4.--Estimated total area infested, annual growth not realized, and annual curtailment on allowable cut in event of European pine shoot moth attack on ponderosa pine, by length of invasion period and temperature criterion

| Minimum temperature criterion | Invasion period | Area infested at end of period | | | Annual growth reduction, end of period | | | Annual reduction of allowable cut during invasion period |
|---|---|---|---|---|---|---|---|---|
| | | Low site | Medium site | Total | Low site | Medium site | Total | |
| | Years | M acres | M acres | M acres | MM bd.ft. | MM bd.ft. | MM bd.ft. | MM bd.ft. |
| -20° F. | 20 | 1,030 | 2,380 | 3,410 | 73 | 728 | 801 | 400 |
| | 50 | 1,780 | 4,120 | 5,900 | 126 | 1,261 | 1,387 | 694 |
| -15° F. | 20 | 100 | 660 | 760 | 7 | 202 | 209 | 104 |
| | 50 | 100 | 1,350 | 1,450 | 7 | 413 | 420 | 210 |

Table 5.--Estimated total annual increment not realized in long run in event of European pine shoot moth attack on ponderosa pine, by site class and temperature zone

| Sites | Annual increment lost, long run | |
|---|---|---|
| | Outside -20° F. zone | Outside -15° F. zone |
| | - - - - - - - - - Million board feet - - - - - - - - - | |
| Low | 775 | 74 |
| Medium | 3,600 | 577 |
| Total | 4,375 | 651 |

High sites, assumed to be unaffected by the shoot moth, are also assumed to be managed intensively in the long run. A mean annual increment of about 670 board feet per acre per year has been estimated for high sites. It follows that, for the long run, total mean annual growth in the ponderosa pine region is estimated to be about 6.8 billion board feet if infestation does not occur. This is almost 80 percent more than United States production of ponderosa pine in 1962. This figure is consistent with the 40-year, medium-level demand projections for lumber and plywood developed in the Timber Resource Review, which suggests more than a doubling of demand for these products.

The likelihood of replacing ponderosa pine with other species has not been discussed. This is a distinct possibility in areas where species associated with ponderosa pine are not themselves susceptible to shoot moth attack. Although failure to analyze species replacement opportunities gives the apparent impact an upward bias, this tends to be offset by omission of impact figures for lodgepole pine.

There is apparently no reasonable means of controlling widespread European pine shoot moth infestations. Therefore, it is important to assess the feasibility of correcting the damage done to the tree by the moth, thereby reducing the impact. One means of doing this is by pruning to remove insect-caused forks.

Talerico and Heikkenen *(11)* explored this method and found that an average of 11 percent of the trees had acquired noncorrectible forks in the preceding 4 years of infestation in red pine plantations attacked by the pine shoot moth. On the normal and correctible trees, an average of 1.4 forks were formed per tree in the 4 years and at the rate of 3.5 forks per tree per decade. If forking were to occur at this rate on the ponderosa pine, it would produce a degree of crooking that would be unacceptable to the log markets. It follows that, on medium sites, the saw log resource would be lost in the event of shoot moth attack unless pruning to correct forking of crop trees were undertaken.

To assess the relative economic merits of pruning versus forsaking saw log production on middle sites, it was necessary to employ a compound interest formula which would compare costs and returns at a common point in time. Both costs and returns were compounded at a 4 percent interest rate to the end of the pine rotation. It was assumed that no other management costs would be affected by a pruning decision.

Experience with pruning dwarfmistletoe infections from ponderosa pine suggests that forking could be corrected on medium sites at a cost of 2 cents per fork.[2] It was assumed that pruning would be done at 10-year intervals beginning at age 10. It appears that pruning would not be necessary beyond age 40. The compounded value of pruning cost per tree is:

3.5 forks per decade X 2 cents per fork = 7 cents per decade
Compounded to age 110 at 4 percent:

| | |
|---|---|
| Pruning at age 10 = | $3.54 |
| Pruning at age 20 = | 2.39 |
| Pruning at age 30 = | 1.61 |
| Pruning at age 40 = | 1.09 |
| Total | $8.63 per tree |

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[2] Costs for pruning dwarfmistletoe infections from ponderosa pine have been studied recently as part of a broad study of dwarfmistletoe control. These results are found in a report in preparation for publication by D.F. Flora, " Economic Guidelines for Ponderosa Pine Dwarfmistletoe Control. "

If it is assumed that a crop tree has 300 board feet when harvested at age 110, that mortality of crop trees is negligible during the rotation, and that a crop tree is worth $15 per thousand board feet as stumpage, then its value when harvested is $4.50. This compares with the cost of $8.63 per tree for pruning, thus implying that pruning is generally not economic for reducing the impact of widespread European pine shoot moth infestation.

# EMPLOYMENT IMPACT

The employment impact of the shoot moth will not be abrupt like a sudden natural catastrophe such as a hurricane. Rather, society should have time to ameliorate its losses by shifting and retraining the labor supply. Estimated here, however, is the employment reduction attributable to shoot moth infestation, without an offsetting estimate of reemployment.

Hair (5) uses a productivity estimate for logging in the West of 59.1 cubic feet per year, moved from the stump to local points of delivery, per man employed in timber harvesting. By use of employment and output figures from the same source, a productivity of 41.3 cubic feet of logs per year per man employed in sawmills in the West was obtained. An arbitrary board-foot/cubic-foot ratio of 5.5 was applied to the estimated shoot moth growth impact.

The ratio of "service" to "basic" employment in counties of Washington and Oregon known to be primarily dependent upon sawmilling was studied. Census data (*12*, table 85) was used. Such ratios, though commonly cited, are sensitive to arbitrary distinctions between basic and nonbasic industries. Basic industries were defined to include manufacturing, logging, agriculture, mining, forestry, and fishing. Nonbasic or service industries include retail and wholesale trade, transportation, utilities, finance, and government. A basic-service ratio of 1:1.26 was derived. This ratio understates the amount of nonlocal wholesaling, transportation, and equipment manufacture and servicing that would be affected by decline of a portion of the forest industry, but an adequate quantitative measure would be difficult to obtain.

An estimate of employment that potentially might be displaced from the ponderosa pine region by shoot moth invasion is given in table 6. It should be noted that the long-run employment figures shown in table 6 represent the difference between anticipated employment under an 80-percent increase in forest output in the West and expected employment under shoot moth infestation. Hence, nearly half of the employment impact in the long run applies to industry expansion foregone rather than present industry displaced.

Table 6.--Potential employment displacement from the ponderosa pine region by European pine shoot moth invasion, by temperature zone and period of time

| Temperature criterion | Average number of workers affected | | |
|---|---|---|---|
| | During 20-year invasion period | During 50-year invasion period | Long run |
| | Persons | | |
| –20° F. | 6,800 | 11,700 | 73,900 |
| –15° F. | 1,800 | 3,600 | 11,000 |

# PAYROLL LOSS

Average income per worker in logging and sawmilling was estimated by dividing total payroll for all employers in these pursuits in the Mountain and Pacific States by the number of loggers and sawmill workers in the same States (*13*, table 2). The resulting average annual income was about $4,650.

Income per worker in the service sector could not be obtained directly. Instead, it was estimated by subtracting total income of forest workers from total income of all workers in selected forest-oriented counties (*12*, table 86) and dividing the result by the number of nonforest workers. Estimated average annual income in the service area thus obtained was about $3,100. This figure unfortunately includes some basic workers; however, their number is small in the counties chosen. These incomes were applied to the aforementioned employment figures to estimate payroll loss in table 7.

Table 7.--Potential annual payroll loss in ponderosa pine region of European pine shoot moth invasion, by temperature zone and period of time

| Temperature criterion | Average annual payroll loss | | |
|---|---|---|---|
| | During 20-year invasion period | During 50-year invasion period | Long run |
| | Million dollars | | |
| –20° F. | 25.6 | 44.4 | 279.9 |
| –15° F. | 6.6 | 13.4 | 41.6 |

# STUMPAGE LOSS

Because the shoot moth attacks only young trees, it is not anticipated that moth invasion would have important effect on local stumpage prices during either a 20- or 50-year invasion. It is supposed that, in the long run under the -20° F. criterion, volume damaged by the shoot moth would be about 5 percent of United States saw log-veneer log consumption, assuming that prices of these products remain generally constant. Assuming an inelastic demand for stumpage and recognizing opportunities to import wood products and develop substitute materials, a longrun price increase of 2 percent is theorized for the -20° F. criterion. Approximately constant stumpage prices are assumed for all other time period-temperature criteria. Stumpage value assumptions follow:

| Site | Stumpage value per M board feet |
|---|---|
|  | (Dollars) |
| Medium | 12 |
| Low | 5 |

There are certain costs associated with the sale of stumpage. If shoot moth infestation reduces the volume of stumpage sold, such costs diminish. Since the costs are largely payments for labor, their reduction represents a loss to those who would receive them. Because it is difficult to identify their level, stumpage-related labor costs have not been subtracted from stumpage values nor included as payroll impact. Presumably, their inclusion as stumpage impact exactly offsets their omission from salary impact.

As with employment, a measurement of the dollar value of timber production foregone by the method used here is rather like taking a bucket of water from a lake. A real void is created, but it is immediately obscured by a countervailing displacement of water nearby. Water closest to the void is displaced farthest. Our problem is to estimate the average displacement throughout the lake and how much the lake level drops, with only the size of our bucket as a guide.

The average annual amounts of stumpage payment reduction expected under different combinations of temperature limitation and invasion period are estimated in table 8.

Table 8.--Average annual total stumpage payment increase in ponderosa pine region of European pine shoot moth invasion, by temperature zone and period of time

| Temperature criterion | Average annual total stumpage payment increase |  |  |
|---|---|---|---|
|  | During 20-year invasion period | During 50-year invasion period | Long run |
|  | Million dollars |  |  |
| -20° F. | 9.1 | 15.8 | 38.7 |
| -15° F. | 2.5 | 5.0 | 7.3 |

# CONCLUSIONS

The potential impact of infestation of the ponderosa pine forests of Western North America by the European pine shoot moth is imposingly large even by the most conservative measures. Such impacts add up to a cumulative disaster over time.

We can also conclude that sensitivity of the European pine shoot moth to low temperatures is a very important determinant of economic impact.

However, the question persists: How much can we justifiably spend to control this insect? At the present time we cannot answer this question. More research is needed on the biology of the shoot moth. More research is needed to determine effective and feasible control measures for widespread infestations. When it becomes possible to predict the effectiveness of alternative control measures (both natural and man induced) at alternative levels of cost, it will be possible to judge whether control would be worthwhile economically in view of the economic values saved through control.

# LITERATURE CITED

(1) Andrews, Stuart R., and Daniels, John P.
1960. A survey of dwarfmistletoes in Arizona and New Mexico. Rocky Mountain Forest & Range Expt. Sta. Sta. Paper 49, 17 pp., illus.

(2) Cowlin, R.W., Briegleb, P.A., and Moravets, F.L.
1942. Forest resources of the ponderosa pine region of Washington and Oregon. U.S. Dept. Agr. Misc. Pub. 490, 99 pp., illus.

(3) Cummings, L.J., and Kemp, Paul D.
1940. Forest increment in north Idaho. North. Rocky Mountain Forest & Range Expt. Sta. Forest Survey Release 18, 74 pp., illus.

(4) Finch, Thomas L.
1951. How fast is timber growing in eastern Montana? North. Rocky Mountain Forest & Range Expt. Sta. Res. Note 88, 7 pp.

(5) Hair, Dwight.
1963. The economic importance of timber in the United States. U.S. Dept. Agr. Misc. Pub. 941, 91 pp., illus.

(6) Heikkenen, Herman J., and Miller, William E.
1960. European pine shoot moth damage as related to red pine growth. Lake States Forest Expt. Sta. Sta. Paper 83, 12 pp., illus.

(7) Kemp, Paul D.
1943. Highlights of the forest situation in western Montana. North. Rocky Mountain Forest & Range Expt. Sta. Forest Survey Statis. Serv. 14, 19 pp. (unnumbered), illus.

(8) ________ and Dickerman, M.B.
1950. Montana forest resource and industry statistics. North. Rocky Mountain Forest & Range Expt. Sta. Sta. Paper 25, 48 pp., illus.

(9) Kincer, Joseph B.
1928. Atlas of American agriculture. Pt. 2, Climate. Sect. B, Temperature, sunshine, and wind. U.S. Dept. Agr. Bur. Agr. Econ., 34 pp., illus.

(10) Pointing, P.J.
1963. The biology and behavior of the European pine shoot moth *Rhyacionia buoliana* (Schiff.) in southern Ontario. Pt. 2, Egg, larva, and pupa. Canad. Entomol. 95: 844-863, illus.

(11) Talerico, R.L., and Heikkenen, H.J.
1962. Stem injury to young red pine by the European pine shoot moth. Jour. Forestry 60: 403-406, illus.

(12) U.S. Bureau of the Census.
1960. Census of population: 1960. General social and economic characteristics. Oregon, pp. 81-168; Washington, pp. 21-86.

(13) ______________
1961. Census of manufactures: 1958. V.2, Industry statistics, Pts. 1 and 2, various pagings.

(14) U.S. Forest Service.
1954. Forest statistics for California. Calif. Forest & Range Expt. Sta. Forest Survey Release 25, 66 pp., illus.

(15) ______________
1958. Timber resources for America's future. Forest Resource Rpt. 14, 713 pp., illus.

(16) Wilson, Alvin K.
1962. Timber resources of Idaho. Intermountain Forest & Range Expt. Sta. Forest Survey Release 3, 42 pp., illus.